

ALKOR -Berichte

**Biodiversity changes and their functional consequences in the
pelagic ecosystems of the central Baltic Sea**

Cruise No. AL521

April 16th – May 2nd 2019

Kiel (Germany) – Kiel (Germany)

BALTIC APRIL



Dr. Jan Dierking

GEOMAR Helmholtz Centre for Ocean Research Kiel

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1 Cruise Summary

1.1 Summary in English

This multidisciplinary cruise extended a long-term data series on ecosystem composition and functioning of the deeper basins of the Baltic Sea that has been collected in similar form since 1987. The key characteristic of the cruise was the integration of oceanographic and biological information to enhance understanding of environmental, plankton dynamics and fish population fluctuations, and ultimately, evolutionary processes in this system. The spatial focus lay on the Bornholm Basin as most important spawning area of Baltic cod, but also included the Western Baltic Sea, Arkona and Gotland Basin, Gdansk Deep, and Stolpe Trench. All objectives of the cruise were achieved, benefiting from perfect weather conditions and flawless performance of all instruments and gear.

The detailed hydrological survey (oxygen, salinity, temperature) of the entire cruise area showed higher water temperatures and an improvement of the oxygen situation in deep water layers compared to the same time period in 2018. Plankton surveys (zoo- and ichthyoplankton including gelatinous plankton, with the goal to determine the composition and the abundance and vertical and horizontal distribution of species, and to take samples for later measurements of nutritional condition) showed a much higher abundance of jellyfish larvae (“ephyrae”) and small adults than in 2018. Regarding fish larvae, sprat and flounder larvae were abundant but very few cod larvae were present throughout the cruise area, both of which was consistent with the situation in previous years. Pelagic fishery hauls were carried out as planned to determine stock structure and to obtain a range of different samples (gonads, livers, stomachs, tissue samples, otoliths) for cod, whiting, sprat and herring as well as different flatfish species, and are the foundation for a range of different individual-level genetic and ecological analyses to be carried out in the laboratory on land. The abundance and distribution of fishes in the cruise area was also assessed continuously over the duration of the cruise with hydroacoustic methods. As in previous years, cod, herring, sprat and flounder dominated catches. Catches of cod increased compared to 2018, but the absence of large cod individuals in particular in Bornholm Basin was consistent with observations in previous years. Finally, the work for all additional collaborative projects, including in-depth sampling of planktonic food webs for dietary tracer work, sampling and experimental work of photosynthesis and respiration rates of different phytoplankton fractions and finally, pelagic fish stomach and plankton sampling for eDNA assessments was carried out successfully.

The resulting data- and sample sets support ongoing projects in the Research Unit Marine Evolutionary Ecology at GEOMAR, as well as the EU Horizon 2020 project GoJelly and several international collaborations.

1.2 Deutsche Zusammenfassung

Diese multidisziplinäre Ausfahrt erweitert eine seit 1987 in ähnlicher Form laufende Lanzitdatenreihe zur Ökosystemzusammensetzung und -funktion der Ostsee mit Schwerpunkt auf die tieferen Becken. Alle Ziele der Ausfahrt wurden erreicht, begünstigt von perfekten Wetterbedingungen und fehlerfreien Performance aller Geräte und Instrumente. Ein Schlüsselmerkmal der Ausfahrt war die Integration ozeanografischer und biologischer Daten, um das Verständnis von Schwankungen in Umweltparametern, Planktongemeinschaften und Fischpopulationen und letztendlich der Evolutionsprozesse in diesem System zu verbessern. Die daraus resultierenden Daten- und Probensätze unterstützen laufende Projekte in der Abteilung Marine Evolutionsökologie am GEOMAR sowie das EU-Horizont 2020-Projekt GoJelly und mehrere internationale Kooperationen. Der räumliche Schwerpunkt lag auf dem Bornholmbecken als wichtigstem Laichgebiet des Ostseedorsches, schloss aber auch die westliche Ostsee, das Arkona- und Gotland-Becken, das Danziger Tief sowie die Stolper Rinne ein.

Die detaillierte hydrologische Untersuchung (Sauerstoff, Salzgehalt, Temperatur) des gesamten Fahrtgebiets ergab höhere Wassertemperaturen und eine Verbesserung der Sauerstoffsituation in tiefen Wasserschichten im Vergleich zum gleichen Vorjahreszeitraum. Planktonuntersuchungen (Zoo- und Ichthyoplankton einschließlich gelatinösem Plankton) mit dem Ziel, die Zusammensetzung und Häufigkeit sowie die vertikale und horizontale Verteilung der Arten zu bestimmen und Proben für spätere Messungen des Ernährungszustands zu entnehmen, zeigten ein deutlich höheres Vorkommen von Quallen-Ephyren als 2018 und ein weit verbreitetes Vorkommen von Sprotten- und Flunderlarven. Die Anzahl der Dorschlarven war wie in den Vorjahren sehr gering. Pelagische Fischereihols zur Bestimmung der Bestandsstruktur, des Reifegrads und der Fruchtbarkeit, sowie der Mageninhalte von Dorsch, Sprotte und Hering, sowie die Entnahme von Organen, Gewebe- und Otolithenproben für genetische und ökologische Analysen des Dorsches wurden wie geplant durchgeführt. Fischbestände wurden außerdem mit Hilfe von Hydroakustikaufnahmen im gesamten Fahrtgebiet erfasst. Wie in den Vorjahren dominierten Dorsch, Hering, Sprotte und Flunder die Fänge. Die Dorschfänge nahmen im Vergleich zu 2018 zu, auffällig war dabei wie schon in den Vorjahren die Abwesenheit großer Dorschindividuen insbesondere im Bornholmbecken. Die eingehende Analyse der resultierenden Proben- und Datensätze steht noch aus.

Zu guter Letzt konnten alle im Rahmen von externen Kollaborationen geplanten Arbeiten, einschließlich der Detailbeprobung planktonischer Nahrungsnetze für die Untersuchung mit Nahrungsnetztracern, der Probenahme und anschließenden experimentellen Arbeiten an Bord zu Photosynthese und Respiration verschiedener Phytoplanktonfraktionen, und der Beprobung der Mägen der pelagischen Fischarten Hering und Sprotte sowie Planktongemeinschaften für eDNA-Analysen, erfolgreich durchgeführt werden.

2 Participants

2.1 Scientific Party

Name	Discipline	Institution ¹
Jan Dierking	Marine Evolutionary Ecology (Chief Scientist)	GEOMAR
Svend Mees	Technician	GEOMAR
Felix Mittermayer ²	Marine Evolutionary Ecology/Postdoc	GEOMAR
Kim Wagner	Biological Oceanography/ MSc Student	GEOMAR
Alba Filella Lopez de Lamadrid ³	Biological Oceanography/MSc Student	GEOMAR
Luisa Listmann	Marine Evolutionary Ecology/Postdoc	UHAM
Peter Hornetz	Fisheries Science/MSc Student	UHAM
Ina Stoltenberg	Marine Ecology/PhD Student	SDU
Silvia Kollerova	Technician	SDU
Christian Pawlitzki	Biology/BSc Student	CAU
Malgorzata Gosia Dembek	Observer	NMFRI
Andreas Novotny ³	Evolutionary ecology/postdoc	SU
Karen Lykkebo ²	Evolutionary ecology/PhD Student	SU

¹Abbreviations explained under Section 2.2.

²First cruise leg Kiel - Kalmar.

³Second cruise leg Kalmar - Kiel.

2.2 Participating Institutions

Abbreviation	Full name
GEOMAR	Helmholtz-Centre for Ocean Research Kiel, Germany
CAU	Christian-Albrechts-Universität zu Kiel, Germany
UHAM	Hamburg University
SDU	University of Southern Denmark
SU	Stockholm University, Sweden
NMFRI	National Marine Fisheries Research Institute, Poland

3 Research Program (including Work Area, Aims and Agenda)

The Baltic Sea is comparatively speaking species poor, yet it provides enormous ecosystems services to the Baltic nations. At the same time, it is one of the systems most affected by the combination of global (including climate) and local anthropogenic changes, and has undergone strong hydrographic and biological shifts in the past decades.

Cruise AL521 extended a 32-year integrative long-term data series of the deep basins of the central Baltic Sea collected since 1987 by the GEOMAR Helmholtz Centre for Ocean Research and its predecessors IFM-GEOMAR Kiel and IFM Kiel. The specific spatial focus was on the Bornholm Basin as most important spawning area of Baltic cod, but also included the western Baltic Sea, Arkona and Gotland Basin and Gdansk Deep (Figure 3.1), thus covering ICES subdivisions (SD) 22, 24, 25, 26 and 28 (Figure 3.2).

The key characteristic of the cruises contributing to this time series is the integration of oceanographic and biological information, to allow the analysis of Baltic pelagic food webs and (fish) species across the environmental gradients of the Baltic Sea, and under changing environmental conditions and human exploitation patterns over time. In this context, the datasets and samples obtained during cruise AL521 are essential for a number of projects, including the large-scale international project EU Horizon 2020 GoJelly and collaborations with the Technical University of Denmark, National Institute of Aquatic Resources (DTU Aqua), Stockholm University, and the University of Hamburg.

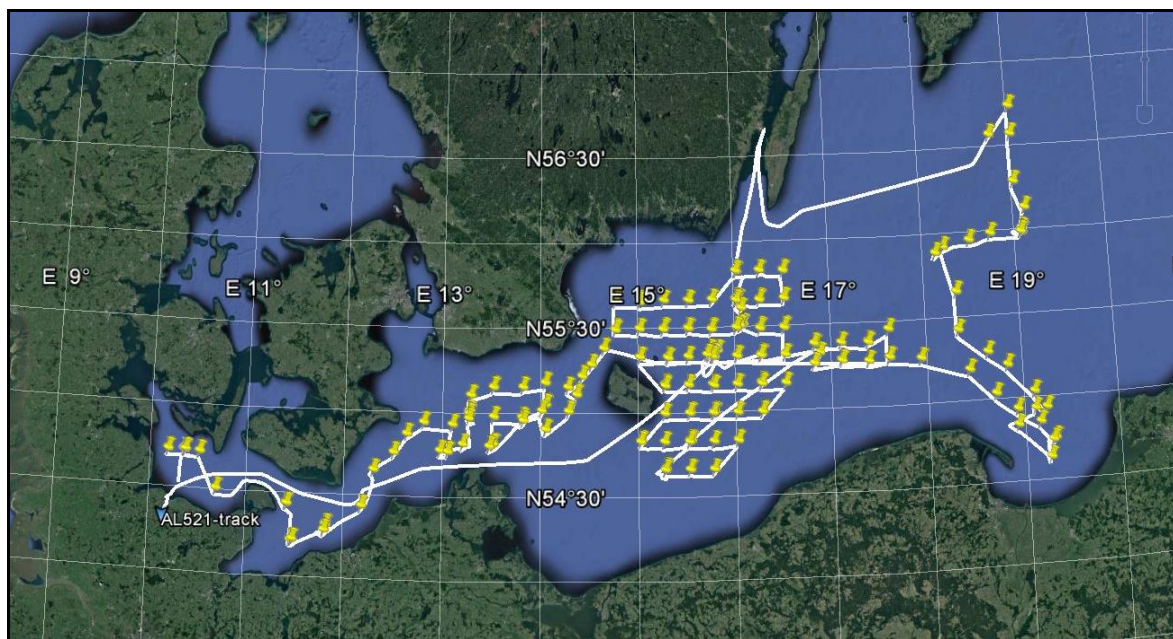


Figure 3.1 Cruise track of AL521, with stations indicated by yellow pins (Map produced in Google Earth).

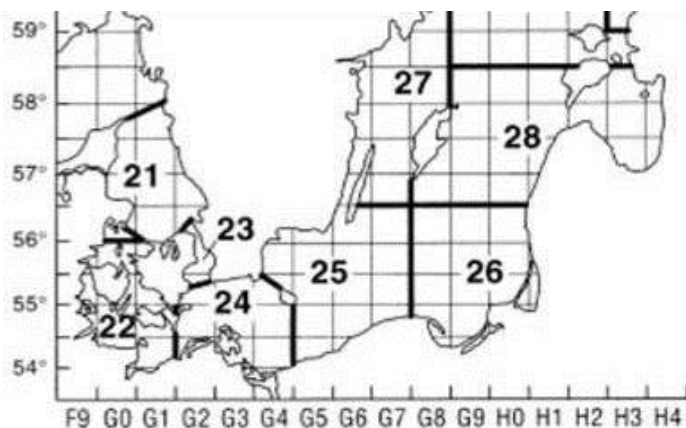


Figure 3.2 ICES subdivisions in the cruise area (Source: ICES). ICES SD22 corresponds to Kiel Bight = KB, SD24 to Arkona Basin = AB, SD25 to Bornholm Basin = BB and Stolpe Trench = SR, SD26 to Gdansk Deep = GD and Southern Gotland Basin (GB).

Specific investigations during AL521 included (1) a detailed hydrographic survey (oxygen, salinity, temperature) (109 stations along the cruise track, see Figure 3.1), (2) zoo- and ichthyoplankton surveys to determine the composition, abundance, vertical and horizontal distribution and nutritional status of species as well as patterns of plankton phenology (same 109 stations, Figure 3.1), (3) whole food web sampling including nutrients, seston, phyto-, zoo- (including jellyfish) and ichthyoplankton (4 stations), and (4) pelagic fishery hauls (25 stations). The latter served firstly to determine size distributions, maturity status, and length – weight relationships of the three dominant fish species in the pelagic system of the Baltic, cod (*Gadus morhua*), herring (*Clupea harengus*) and sprat (*Sprattus sprattus*) as well as flatfishes including flounder (*Plathichthys flesus*). Secondly, various samples for more detailed analyses back on land were obtained, including cod gonads, livers and otoliths, herring and sprat stomachs and whole samples for dietary analyses, and tissue samples of cod, flounder, whiting, plaice and other species for genetic and stable isotope analysis. In addition, hydroacoustic data were collected continuously along the cruise track for later analysis of fish abundance and distribution. Finally, additional work in the context of collaborations with external groups were (5) sampling and experimental work of photosynthesis and respiration rates of different phytoplankton fractions and (6) pelagic fish stomach and plankton sampling for eDNA assessments.

4 Narrative of the Cruise

RV ALKOR was loaded on the days prior to the onset of the cruise. ALKOR then departed from the GEOMAR Westshore pier on April 16 2019 at 08:00 am (all times board time) and headed to the first research area in Kiel Bight (SD22). In the following, all work laid out in the original cruise program was accomplished as planned, benefiting from perfect working conditions on board without any equipment problems. Weather over the duration of the cruise was calm, warm and mostly sunny, in an unusual departure from weather patterns experienced during April cruises in the same working area in previous years.

Over the course of the cruise, pelagic fishery hauls, zooplankton hauls with Bongo/IKS-80 nets, water sampler, and CTD hauls were carried out following a large-scale spatial sampling design covering Kiel Bight (SD22) on April 16, Mecklenburg Bight (SD22) on April 17, Arkona Basin (SD24) on April 18-19, Bornholm Basin (SD25) on April 20 and again in more detail from April 25 to May 1, Stolpe Trench (SD25) on April 20, Gdansk Deep (SD26) on April 21-22, and Gotland Basin (SD26) on April 23 (Figure 3.1, 3.2). Hydroacoustic data obtained with four different echosounder frequencies (38, 70, 120 and 200 kHz) were continuously recorded over the duration of the cruise.

The scientific work was interrupted by a scheduled harbor stay in Kalmar, Sweden on April 23-25 to disembark two scientists and embark two replacements. The stay was extended by one day due to a passing low pressure system and strong winds in the cruise area on April 24.

In addition to the program above, the central deep station BB23 in Bornholm Basin was intensively sampled on two occasions, early in the cruise on April 20 (including CTD casts, zooplankton sampling with Bongo, Apstein and WP-2 nets, oxygen measurements of water samples obtained with the rosette water sampler with the Winkler method for the calibration of oxygen probe measurements, and phytoplankton sampling) and late in the cruise on April 30 – May 1 (same sampling as on April 18, followed by the detailed vertically and temporally resolved sampling of plankton communities by four towed Multinet MAXI and four vertical Multinet MIDI hauls over a 24 hour period, covering the water column in 5 m and 10 m depth layers, respectively). Moreover, whole food web samples (nutrients, seston, phyto- and zooplankton including jellyfish and fish larvae) were obtained at 4 stations, using a combination of water sampler, Bongo, WP-2 and WP-3 hauls. Additional sampling was carried out throughout the cruise area for the special projects on phytoplankton communities (surface water samples at 16 stations) and on eDNA assessments of pelagic fish diets (7 stations). Table 4.1 provides a spatially resolved overview over all gear deployments during AL521.

Table 4.1 Overview of gear deployments during AL521. Mesh sizes of all nets are given in brackets. For location designations (combination of ICES SD and abbreviated name), see Figure 3.2.

	22 - KB	22 - MB	24 - AB	25 - BB	25 - SR	26 - GB	26 - GD	Total
Apstein net (50 µm)				6				6
Bo/BaBo net 150, 300, 500 (µm)	5	4	24	53	6	2		94
CTD probe	4	3	23	48	10	11	10	109
IKS-80 net (500 µm)					5	10	10	25
Pelagic fishery trawl net (0.5 cm)	1	3	6	7	1	3	4	25
Multinet-MAXI net (335 µm)				9				9
Multine-MIDI net (50 µm)				9				9
WP2 net (100 µm)	1		1	11		2		15
WP2 net (200 µm)	3		1	7		3		14
WP3 net (1000 µm)	1	1		2		1		5
Rosette water sampler + CTD	1		1	10		2		14
Small water sampler	2	3	4	5		1		15
Total	18	14	60	167	22	35	24	340

5 Preliminary Results

5.1 Ichthyo- and zooplankton sampling

Bongo- and Babybongo hauls covered Kiel Bight (5 hauls), Mecklenburg Bight (4 hauls), Arkona Basin (24 hauls), and Bornholm Basin including the western part of Stolpe Trench (53 hauls) (Table 4.1). Larvae of sprat (*Sprattus sprattus*; n = 1027), flounder (*Plathichthys flesus*; n = 677), sculpin (*Myoxocephalus scorpius*, n = 2), common seasnail (*Liparis liparis*; n = 67) and sandeel (*Ammodytes tobianus*; n = 1) were picked from the 500 µm bongo-samples and 300 µm Multinet samples and conserved at -80 °C for subsequent RNA/DNA, stable isotope and genetic analyses. A low number (n = 6) of cod (*Gadus morhua*) larvae was found. This compares to a complete lack of cod larvae in catches in 2018, but is generally consistent with low abundances observed on our spring cruises in previous years. It also fits the observation of a long-term, decadal scale shift in the reproductive period and the subsequent occurrence of cod larvae in the Bornholm Basin from spring to summer months.

All of the 500 µm Bongo und the 300 µm Multinet MAXI samples were also checked for the presence of gelatinous zooplankton. Ephyrae (larvae) and small adults of scyphozoan jellyfish (identified on board as *Cyanea capillata*, potentially low numbers of *Aurelia aurita*) were present in much higher abundances than in 2018 (n = 1550 vs. less than 10), whereas the invasive combjelly *Mnemiopsis leidyi* was present only in low numbers (n = 5). A possible explanation may lie in the much higher water temperatures in 2019 compared to the same period in 2018, and possible effects on the phenology of gelatinous zooplankton. Following these initial on board steps, all Bongo samples were conserved in formol, and are available for the determination of species composition and abundance of zoo- and ichthyoplankton.

Stations in the eastern part of Stolpe trench and in the Gdansk Deep and Southern Gotland Basin were sampled with IKS-80 nets instead of Bongo nets to ensure the compatibility

of data with a long-term IKS-80 sampling series maintained by the Latvian Fish Resources Agency (LATFRA; Andrei Makarcuks).

Repeated Multinet MAXI (300 μm , towed, sampling of the water column in 5 m layers) and MIDI (50 μm , vertical, sampling of the water column in 10 m layers) casts were done over a 24 hour period on April 30 – May 1 on the central deep Bornholm Basin station BB23 to assess diurnally resolved vertical distributions of ichthyo- and zooplankton. A notable pattern here was the different depth distribution of jellyfish (centered around the 50-55 m depth line, little diurnal vertical variation) and fish larvae (e.g., sprat: diurnal migration from depths around 20 m during the day to the surface at night) (Figure 5.1.1).

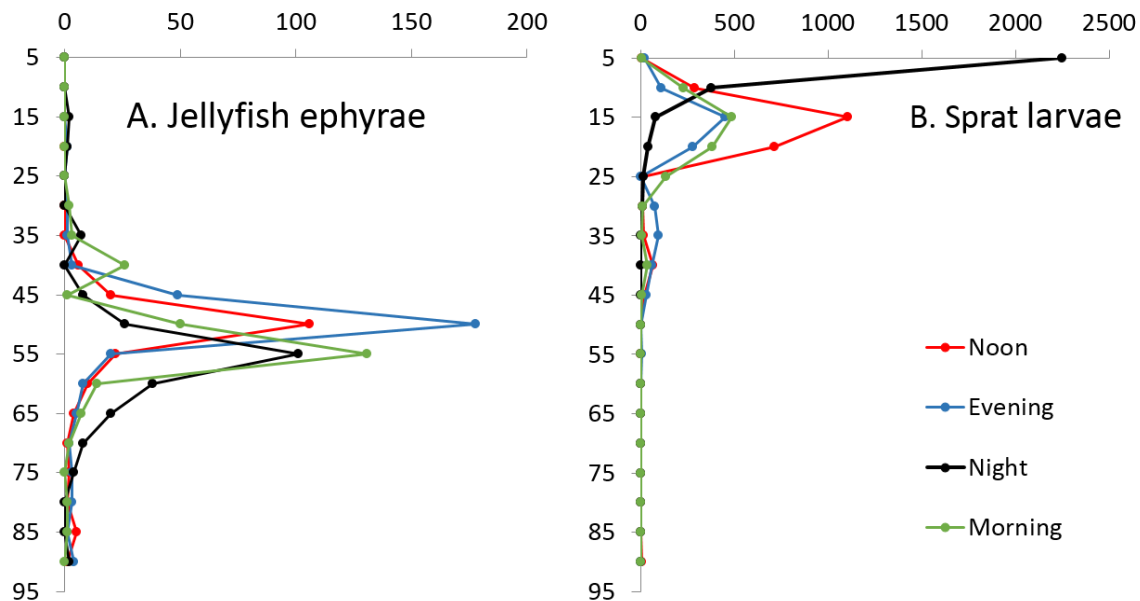


Figure 5.1.1 Depth distribution of A. jellyfish ephyrae (*Cyanea capillata*) and B. sprat (*Sprattus sprattus*) larvae observed on the central Bornholm Basin station BB23 over a 24 hour period on April 30 – May 1 2019.

5.2 Fishery

Pelagic fishery hauls were conducted in Kiel Bight (1 haul), Mecklenburg Bight (3 hauls) Arkona Basin (6 hauls), Bornholm Basin (7 hauls), Stolpe Trench (1 haul), Gotland Basin (3 hauls) and Gdansk Deep (4 hauls) (Table 4.1).

Catches of cod in Mecklenburg Bight, which was sampled for the first time in 2019 on one of our April cruises, stood out in being much higher and characterized by on average larger individuals than in our “standard operating areas” in SD24-26. While own prior data for comparison are lacking, this observation is consistent with findings of collaborators e.g., in March and August in the same area (personal communication Jens-Peter Herrmann, Hamburg University). For SD24-26, catches of cod were higher than for the same time period in 2018. This may in part be explained by improved catchability due to higher oxygen concentrations (see Section 5.3) and resulting higher cod densities near the bottom compared to the more vertically dispersed distribution in 2018. Catches of sprat and flatfishes were higher and of herring somewhat lower than in previous years. It is however important to note that direct quantitative comparisons of catches between years are difficult because the trawls are not standardized. The overall catch composition is shown in Table 5.2.1.

Table 5.2.1 Fish catch composition for AL521. Single fish measurement and samples were taken for 900 cod and 219 whiting individuals. For herring and sprat, sub-samples were taken at each station. For flatfishes and all other species, measurements and fin clips of all individuals were taken.

Latin name	Common name	n	mass (kg)
<i>Sprattus sprattus</i>	sprat	402,136	3,758.5
<i>Clupea harengus</i>	herring	7,721	300.2
<i>Gadus morhua</i>	cod	1,531	604.7
<i>Merlangius merlangus</i>	whiting	667	116.7
<i>Platichthys flesus</i>	flounder	163	30.5
<i>Limanda limanda</i>	common dab	440	75.2
<i>Pleuronectes platessa</i>	plaice	199	41.1
<i>Gasterosteus aculeatus</i>	three-spined stickleback		5.8
<i>Rhinonemus cimbrius</i>	four bearded rockling	2	0.2
Other species		31	8.3
Total		412,890	4,941

For cod, single fish data (length, weight, sex and maturity stage) and samples (otoliths, fin clips for genetic analysis, gonads and livers) were obtained for 900 individuals in total (see Figure 5.2.2 for illustration). Length and weight were measured for an additional 631 individuals. In Bornholm Basin, the main spawning area of Baltic cod, the mean size of individuals had declined to 31.1 cm from 32.9 cm in 2018 (Figure 5.2.1), and larger individuals >45 cm, which were frequently observed in past decades, were mostly absent from the population. Both of these observations are consistent with temporal trends over past years, and represent a dramatic difference from size distributions in the 1980s and 1990s, when much larger larger individuals were prevalent in the population.

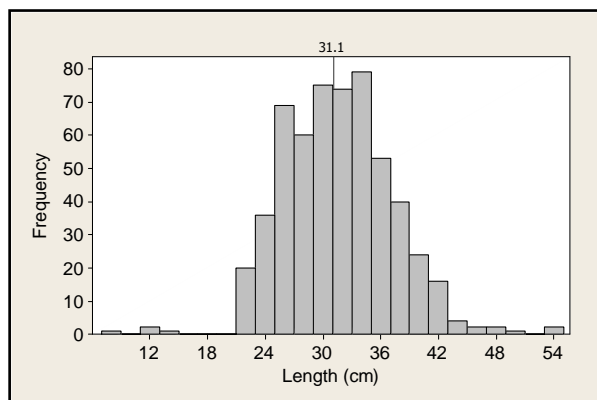


Figure 5.2.1 Length frequency distribution of cod sampled in SD25 during AL521 (n = 561). The mean size of individuals, 31.1 cm, is marked on the x-axis, and compares to 32.9 cm in 2018.



Figure 5.2.2 Samples (otoliths, fin clips, gonads, livers) and measures (total length, weight, gutted weight, liver and gonad weight) were taken from 900 out of 1531 cod individuals (illustrated here for a 38 cm female, maturity stage IV, with full stomach, from Bornholm Basin). Photo: S. Nickel

For sprat and herring, stomach samples (sprat: 20 per 1 cm length class; herring: 20 per 2 cm length class) as well as 2 kg frost samples were taken at each station.

5.3 Hydrography

CTD profiles were obtained with the ADM-CTD (109 stations) and the HYDROBIOS water sampler with attached CTD (14 stations). Two additional vertical oxygen profiles were obtained for calibration purposes at the deep central Bornholm Basin station BB23 and the Gotland Basin station GB79, by determining oxygen concentrations in depth resolved water samples taken with the water sampler using the Winkler method.

Compared to the same time period in 2018, oxygen concentrations in the deeper layers of Bornholm Basin but also Gdansk Deep showed an increase, and the extent of areas with anoxic (0 ml/l) or hypoxic (< 2 ml/l) conditions at depths below of 70 m and down to the bottom declined. Consequently, the reproductive volume for cod increased. Temperatures above the halocline were in the range of ~6°C compared to ~3 °C in the same period in 2018, i.e., clearly higher. In the western Baltic Sea (SD22 - Mecklenburg Bight and the western part of SD24 - Arkona Basin), surface salinities were clearly reduced, around 9 psu vs. 11-15 in previous years, which was likely related to a consistent period of easterly winds that prevailed right up to the start of the cruise, pushing low salinity surface waters from more eastern areas westwards. The combined observations of environmental parameters and the differences compared to the same time period in 2018 once again underscored the strong potential for fluctuations in environmental conditions from year to year on top of any long-term changes that are taking place in the Baltic.

5.4 Food web structure of pelagic systems in the deep basins of the Baltic Sea (Ina Stoltenberg, Jan Dierking, EU Horizon 2020 project GoJelly)

Work during AL521 was a continuation of sampling efforts that took place during the ALKOR cruises AL507 and 509 in April and May 2018 (see the respective cruise reports for details). The project aims to provide better understanding of the role of jellyfish in marine food webs, with a focus on the interactions between jellyfish and commercially important fish species. In GoJelly, the Baltic Sea is as one of several case study areas to address these topics, with other areas including Norwegian Fjords, Madeira in the North Atlantic and the eastern Mediterranean.

During AL521, four stations (KB06 in Kiel Bight, BB15 and 23 in Bornholm Basin, and GB79 in Gotland Basin) were intensively sampled to obtain sample sets for later analyses of fatty acid and stable isotope composition as food web markers. This included jellyfish ephyrae and small medusae, fish adults and larvae, and the main representatives of lower trophic levels (e.g., copepods, cladocerans). Additionally, phytoplankton and water samples were taken for chlorophyll, carbon to nitrogen ratios, bacteria and nutrient measurements. All sampling was carried out as planned, resulting in a total set of 403 samples for food web analysis and additional analyses back in the laboratory on land. Additionally, tissue samples of 294 jellyfish individuals were taken to support genetic analyses of Norwegian GoJelly partners at NTNU.

5.5 Importance of zooplankton species as prey for fish larvae in the Baltic Sea assessed with eDNA analysis (Andreas Novotny, Karen Petersen, Monika Winder, Stockholm University, in collaboration with the Research Unit Marine Evolutionary Ecology at GEOMAR)

This research project based at Stockholm University aims to study ecosystem-wide species interactions in the Baltic Sea. By applying DNA metabarcoding to field collected specimens we want to increase our understanding of each species ecological niche and trophic positioning, and answer the question “who eats whom?”. The main objective during AL521 was to expand our studies beyond plankton-plankton interactions and include larger consumers such as fish larvae and fish. We collected samples from bacteria and phytoplankton communities, micro- and mesozooplankton, fish larvae (sprat and flounder) and adult fish stomachs from sprat, herring and sticklebacks and preserved them for later DNA analysis. Samples were collected in Kiel

Bight (KB06), Arkona Basin (H22), Gotland Basin (BG79), and the Bornholm basin (BB07, BB15, BB23, and BB35). Given the taxonomic and spatial coverage of the sampling, this cruise turned out successful and the objectives were accomplished. As next steps, the diversity of *16S* and *18S rRNA* genes associated with the content of fish stomachs and guts will be analysed on an Illumina MiSeq sequencing platform during summer and fall 2019. We are also developing a quantitative PCR assay to be able to estimate the proportions of copepods, rotifers and cladocerans in the diet of planktivorous fish and fish larvae.

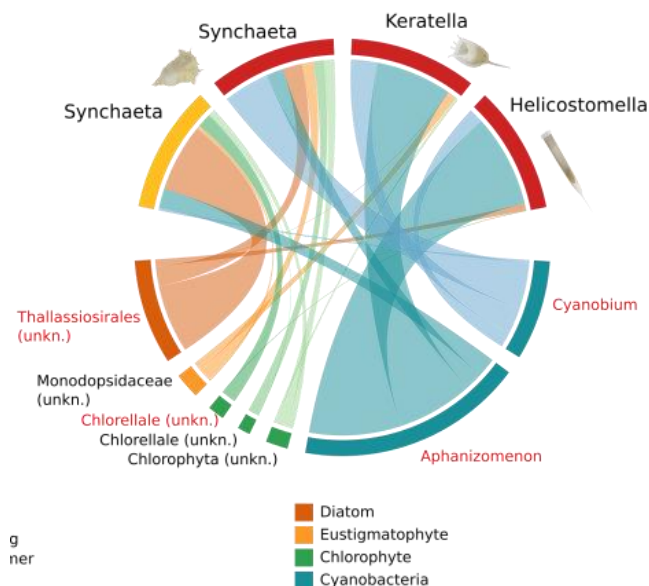


Figure 5.5.1 Output of own previous work (in progress) illustrating the proportion of different food items (lower) associated with different consumers (upper - in this case microzooplankton).

5.6 Marine microbes and viruses of the Baltic Sea under climate change (Luisa Listmann, Elisa Schaum, Hamburg University, in collaboration with the Research Unit Marine Evolutionary Ecology at GEOMAR)

As part of this project on the ecological and evolutionary effects of different temperatures and salinities in the Baltic Sea on phytoplankton, we aim to answer the following questions: a) Does the short-term physiological response of picoplankton to temperature and salinity differ between samples from different regions of the Baltic Sea? b) From which regions of the Baltic Sea can we isolate *Ostreococcus* sp. and its associated viruses?

To help answer these questions, we took surface water samples at 16 stations along the cruise track of AL521. On board, we measured photosynthesis and respiratory activity of two different size fractions (0.2-2 μm and 0.2-37.5 μm) immediately after sampling, and assessed these responses over a gradient of salinity and temperature. Furthermore, water samples of the smaller size fractions were set aside to isolate viruses and picoplankton back in the laboratory at the institute in Hamburg. The 16 stations were divided into Kiel Bay (1 station), Mecklenburg Bay (3 stations), the Arkona Basin (4 stations), the Bornholm Basin (6 stations) and the southern Gotland Basin (1 station).

Preliminary analyses of the temperature curves (see Figure 5.6.1) show that the size fractions differ in their metabolic activity, but also point to differences between different regions along the salinity gradient of the Baltic Sea. In-depth analyses are ongoing, and point toward regional environmental forcing (e.g. comparisons between Bornholm Basin and Kiel Bight) having an impact on par with that of seasonal forcing (e.g. comparisons between spring and summer). Our results suggest that while populations from either region can swiftly adjust their metabolic profiles along gradients of environmental change, the underlying mechanisms differ.

For samples from the Bornholm Basin, rapid species sorting seems to explain most of the responses, whereas samples from Kiel Bight tend to respond to environmental change through sorting within the same species and phenotypic plasticity. In-depth analyses are ongoing. Further, we have had first lysis successes pointing toward the presence of lytic host-virus pairs across the Baltic Sea Basins.

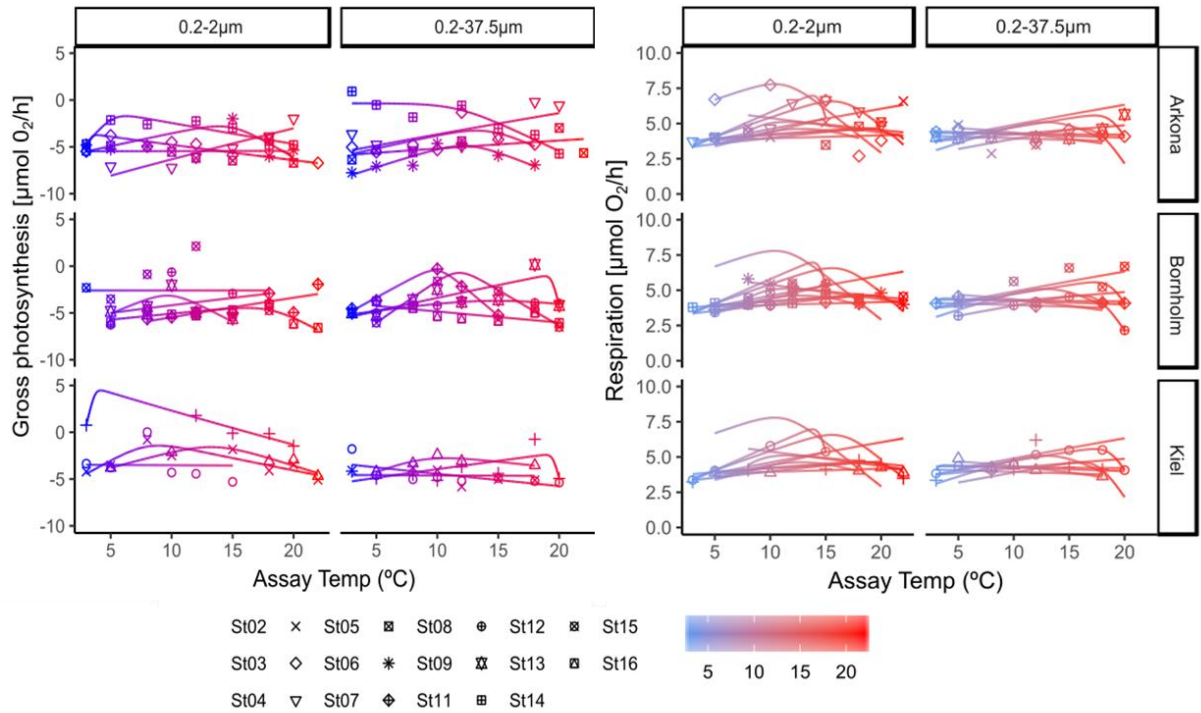


Figure 5.6.1 Temperature reaction norms based on raw data from size fractionated on-board incubations of Kiel Bight, Arkona, and Bornholm samples across a temperature gradient (3°C - 20°C). The left-hand side is for photosynthesis rates in $\mu\text{mol O}_2 \text{ h}^{-1}$, and the right-hand side, for respiration rates in $\mu\text{mol O}_2 \text{ h}^{-1}$. Symbols denote different stations, and the colour gradient the assay temperature (warm – red; cold – blue). Fraction and basin both explain most of the variability found within the temperature profiles. These data were normalized for biomass upon arrival in Hamburg, which changes the intercept, but not the shape of the curves.

6 Station List

In total, 340 gear deployments took place during this cruise (see Table 4.1 for an overview, and Table 6.1 for the full station list). The electronic version of the list and additional cruise data are also permanently available via the GEOMAR OSIS data portal under the link:

<https://portal.geomar.de/metadata/leg/show/348646>.

Table 6.1 Station list with all 340 gear deployments during of AL521

Gear	Gear nr	Station nr	SD	Station	Year	Date	Time	Lat.	Long.	Depth	Duration
CTD	1	1	22	KB06	2019	4/16/2019	10:21	544150	102039	27	0:04
WS-klein	1	1	22	KB06	2019	4/16/2019	10:28	544140	102050	27	0:02
JFT	1	1	22	KB06	2019	4/16/2019	10:49	544140	102180	27	0:36
Bo/BaBo 150, 300, 500	1	2	22	KB03	2019	4/16/2019	15:28	544117	101035	20	0:04
CTD	2	2	22	KB03	2019	4/16/2019	15:38	544149	101007	19	0:03
WS-CTD	1	3	22	KB06	2019	4/16/2019	16:19	544151	102037	27	0:10
Bo/BaBo 150, 300, 500	2	3	22	KB06	2019	4/16/2019	16:45	544156	102098	27	0:05
Bo/BaBo 150, 300, 500	3	3	22	KB06	2019	4/16/2019	16:58	544137	102055	25	0:05
Bo/BaBo 150, 300, 500	4	3	22	KB06	2019	4/16/2019	17:09	544141	101990	25	0:04
WP2 200	1	3	22	KB06	2019	4/16/2019	18:01	544151	102043	27	0:03
WP2 200	2	3	22	KB06	2019	4/16/2019	18:08	544151	102044	27	0:03

WP2 200	3	3	22	KB06	2019	4/16/2019	18:13	544150	102043	27	0:04
WP2 100	1	3	22	KB06	2019	4/16/2019	18:20	544147	102044	27	0:03
WP3 1000	1	3	22	KB06	2019	4/16/2019	18:27	544149	102047	27	0:03
Bo/BaBo 150, 300, 500	5	4	22	KB12	2019	4/16/2019	19:05	544092	102939	28	0:04
CTD	3	4	22	KB12	2019	4/16/2019	19:13	544098	102984	28	0:04
CTD	4	5	22	KBLL	2019	4/16/2019	20:48	542806	104050	19	0:01
WS-klein	2	6	22	KBLL	2019	4/16/2019	20:51	542807	104050	19	0:02
CTD	5	7	22	MB3	2019	4/17/2019	5:57	542390	112376	23	0:03
WS-klein	3	7	22	MB3	2019	4/17/2019	6:03	542390	112376	23	
Bo/BaBo 150, 300, 500	6	7	22	MB3	2019	4/17/2019		542390	112276	23	0:00
JFT	2	7	22	MB3	2019	4/17/2019	6:38	542355	112618	23	
Bo/BaBo 150, 300, 500	7	7	22	MB2	2019	4/17/2019	9:46	541124	112755	24	0:04
WS-klein	4	8	22	MB2	2019	4/17/2019	9:54	541130	112798	24	0:01
CTD	6	8	22	MB2	2019	4/17/2019	10:01	541129	112797	24	0:03
JFT	3	8	22	MB2	2019	4/17/2019	10:30	541105	112781	24	0:30
CTD	7	9	22	MB1	2019	4/17/2019	13:45	541691	114831	25	0:04
Bo/BaBo 150, 300, 500	8	9	22	MB1	2019	4/17/2019	13:53	541692	114832	25	0:04
WS-klein	5	9	22	MB1	2019	4/17/2019	14:02	541699	114843	25	
JFT	4	9	22	MB1	2019	4/17/2019	14:22	541731	114910	25	0:30
WP3 1000	2	9	22	MB1	2019	4/17/2019	20:45	544149	114730	25	0:04
Bo/BaBo 150, 300, 500	9	9	22	MB1	2019	4/17/2019	20:54	541497	114735	25	0:03
Bo/BaBo 150, 300, 500	10	10	24	H31	2019	4/17/2019	22:32	542385	120959	21	0:03
CTD	8	10	24	H31	2019	4/17/2019	22:40	542399	120991	22	0:02
CTD	9	12	24	H30	2019	4/18/2019	0:20	543698	121698	20	0:02
Bo/BaBo 150, 300, 500	11	12	24	H30	2019	4/18/2019	0:26	543702	121694	20	0:03
Bo/BaBo 150, 300, 500	12	13	24	H29	2019	4/18/2019	1:29	544326	122901	19	0:02
CTD	10	13	24	H29	2019	4/18/2019	1:35	544337	122910	19	0:02
CTD	11	14	24	H28	2019	4/18/2019	2:26	544998	123694	17	0:02
Bo/BaBo 150, 300, 500	13	14	24	H28	2019	4/18/2019	2:31	545003	123703	17	0:03
Bo/BaBo 150, 300, 500	14	15	24	H27	2019	4/18/2019	3:15	545412	124724	26	0:04
CTD	12	15	24	H27	2019	4/18/2019	3:22	545437	124741	27	0:03
CTD	13	16	24	H23	2019	4/18/2019	4:24	545349	130484	45	0:04
Bo/BaBo 150, 300, 500	15	16	24	H23	2019	4/18/2019	4:30	545353	130495	45	0:06
Bo/BaBo 150, 300, 500	16	17	24	H25	2019	4/18/2019	5:34	544380	130197	23	0:03
CTD	14	17	24	H25	2019	4/18/2019	5:41	544400	130235	24	0:03
WS-klein	6	17	24	H25	2019	4/18/2019	6:06	544418	125739	30	0:01
JFT	5	17	24	H25	2019	4/18/2019	6:23	544570	125836	26	0:30
JFT	6	18	24	H24	2019	4/18/2019	9:20	544697	131225	43	0:35
JFT	7	19	24	H22	2019	4/18/2019	14:05	545600	131624	47	0:30
CTD	15	19	24	H22	2019	4/18/2019	18:52	545754	131499	48	0:04
WS-CTD	2	19	24	H22	2019	4/18/2019	19:07	545707	131507	48	0:13
WP2 100	2	19	24	H22	2019	4/18/2019	19:26	545751	131501	48	
WP2 200	4	19	24	H22	2019	4/18/2019	19:36	545750	131501	48	
Bo/BaBo 150, 300, 500	17	19	24	H22	2019	4/18/2019	19:46	545760	131502	48	0:07
Bo/BaBo 150, 300, 500	18	19	24	H22	2019	4/18/2019	20:10	545846	131499	48	0:06
CTD	16	20	24	H02	2019	4/18/2019	20:56	550400	131604	45	0:04
WS-klein	7	21	24	H02	2019	4/18/2019	21:03	550401	131605	45	0:02
Bo/BaBo 150, 300, 500	19	21	24	H02	2019	4/18/2019	21:08	550407	131619	44	0:06
Bo/BaBo 150, 300, 500	20	22	24	H04	2019	4/18/2019	22:03	550685	132977	45	0:07
CTD	17	22	24	H04	2019	4/18/2019	22:14	550724	133014	45	0:06
CTD	18	23	24	H05	2019	4/18/2019	23:23	550699	134796	46	0:04
Bo/BaBo 150, 300, 500	21	23	24	H05	2019	4/18/2019	23:30	550707	134800	46	0:07
Bo/BaBo 150, 300, 500	22	24	24	H06	2019	4/19/2019	0:23	550853	140163	46	0:07
CTD	19	24	24	H06	2019	4/19/2019	0:34	550888	140189	46	0:04
CTD	20	25	24	H17	2019	4/19/2019	1:24	550101	140199	49	0:03

Bo/BaBo 150, 300, 500	23	25	24	H17	2019	4/19/2019	1:30	550099	140195	49	0:07
Bo/BaBo 150, 300, 500	24	26	24	H18	2019	4/19/2019	2:28	545626	134759	48	0:07
CTD	21	26	24	H18	2019	4/19/2019	2:39	545644	134703	48	0:03
CTD	22	27	24	H21	2019	4/19/2019	3:37	545648	132999	48	0:03
Bo/BaBo 150, 300, 500	25	27	24	H21	2019	4/19/2019	3:43	545650	132998	48	0:06
Bo/BaBo 150, 300, 500	26	28	24	H20	2019	4/19/2019	4:42	544679	132959	44	0:06
CTD	23	28	24	H20	2019	4/19/2019	4:52	544704	133017	44	0:04
WS-klein	8	29	24	H20	2019	4/19/2019	5:56	544593	132736	43	
JFT	8	29	24	H20	2019	4/19/2019	6:20	544640	132907	43	0:30
JFT	9	30	24	H18	2019	4/19/2019	10:27	545548	134856	48	0:30
JFT	10	31	24	H17	2019	4/19/2019	14:39	545922	140004	49	
WS-klein	9	31	24	H17	2019	4/19/2019		550101	140199		0:00
Bo/BaBo 150, 300, 500	27	32	24	H16	2019	4/19/2019	19:40	545208	140192	43	0:07
CTD	24	32	24	H16	2019	4/19/2019	19:52	545202	140195	43	0:05
CTD	25	33	24	H15	2019	4/19/2019	20:59	545847	141597	43	0:04
Bo/BaBo 150, 300, 500	28	33	24	H15	2019	4/19/2019	21:05	545852	141602	43	0:06
Bo/BaBo 150, 300, 500	29	34	24	H14	2019	4/19/2019	21:49	550435	142092	47	0:07
CTD	26	34	24	H14	2019	4/19/2019	22:00	550473	142112	47	0:04
CTD	27	35	24	H07	2019	4/19/2019	22:34	550697	141549	49	0:06
Bo/BaBo 150, 300, 500	30	35	24	H07	2019	4/19/2019	22:43	550703	141576	49	0:07
Bo/BaBo 150, 300, 500	31	36	24	H12	2019	4/19/2019	23:29	551083	142430	46	0:06
CTD	28	36	24	H12	2019	4/19/2019	23:39	551117	142429	46	0:04
CTD	29	37	24	H11	2019	4/20/2019	0:14	551501	143002	46	0:04
Bo/BaBo 150, 300, 500	32	37	24	H11	2019	4/20/2019	0:20	551506	143008	46	0:07
Bo/BaBo 150, 300, 500	33	38	24	H10	2019	4/20/2019	1:03	552059	143766	53	0:07
CTD	30	38	24	H10	2019	4/20/2019	1:03	552088	143791	53	0:07
CTD	31	39	25	BB23	2019	4/20/2019	5:59	551750	154498	98	0:09
WS-CTD	3	39	25	BB23	2019	4/20/2019	6:14	551748	154497	98	0:09
WP2 100	3	39	25	BB23	2019	4/20/2019	6:32	551749	154500	98	0:12
WP2 100	4	39	25	BB23	2019	4/20/2019	6:47	551750	154500	98	0:13
WP2 100	5	39	25	BB23	2019	4/20/2019	7:03	551750	154500	98	0:11
WP2 100	6	39	25	BB23	2019	4/20/2019	7:16	551749	154500	98	0:11
Apstein 50	1	39	25	BB23	2019	4/20/2019	7:35	551749	154500	98	0:19
Apstein 50	2	39	25	BB23	2019	4/20/2019	7:56	551749	154500	98	0:19
Apstein 50	3	39	25	BB23	2019	4/20/2019	8:19	551749	154500	98	0:18
WS-CTD	4	39	25	BB23	2019	4/20/2019	8:43	551750	154498	98	0:19
WS-CTD	5	39	25	BB23	2019	4/20/2019	9:32	551749	154498	98	0:11
WP2 200	5	39	25	BB23	2019	4/20/2019	9:50	551749	154506	98	0:12
WP2 200	6	39	25	BB23	2019	4/20/2019	10:11	551751	154501	98	0:11
WP3 1000	3	39	25	BB23	2019	4/20/2019	10:30	551749	154500	98	0:11
Bo/BaBo 150, 300, 500	34	39	25	BB23	2019	4/20/2019	10:48	551756	154484	98	0:15
Bo/BaBo 150, 300, 500	35	39	25	BB23	2019	4/20/2019	11:12	551801	154300	98	0:14
Bo/BaBo 150, 300, 500	36	39	25	BB23	2019	4/20/2019	11:32	551810	154142	98	0:13
MN-maxi 335	1	39	25	BB23	2019	4/20/2019	12:53	551804	154270	98	0:26
MN-midi 50	1	39	25	BB23	2019	4/20/2019	13:49	551747	154498	98	0:11
IKS-80 500	1	40	25	SR49	2019	4/20/2019	19:33	551494	173497	84	0:06
CTD	32	40	25	SR49	2019	4/20/2019	19:43	551493	173502	84	0:06
CTD	33	41	25	SR50	2019	4/20/2019	20:59	551399	175497	64	0:06
IKS-80 500	2	41	25	SR50	2019	4/20/2019	21:07	551401	175498	66	0:05
IKS-80 500	3	41	25	SR50	2019	4/20/2019	21:15	551402	175498	65	
IKS-80 500	4	42	26	GD56	2019	4/20/2019	23:05	550899	182504	82	
CTD	34	42	26	GD56	2019	4/20/2019	23:11	550897	182502	82	0:06
CTD	35	43	26	GD59a	2019	4/21/2019	0:30	545997	184093	95	0:07
IKS-80 500	5	43	26	GD59a	2019	4/21/2019	0:40	545994	184092	95	0:07
IKS-80 500	6	44	26	GD59	2019	4/21/2019	1:43	545399	185400	90	0:06

CTD	36	44	26	GD59	2019	4/21/2019	1:53	545397	185399	90	0:06
CTD	37	45	26	GD60	2019	4/21/2019	2:53	544896	190798	96	0:06
IKS-80 500	7	45	26	GD60	2019	4/21/2019	3:02	544896	190797	96	0:07
IKS-80 500	8	46	26	GD60a	2019	4/21/2019	3:55	544297	191692	97	0:08
CTD	38	46	26	GD60a	2019	4/21/2019	4:06	544294	191683	95	0:07
JFT	11	47	26	GD60a	2019	4/21/2019	6:24	544271	191500	98	
JFT	12	48	26	S-GD60a	2019	4/21/2019	9:19	543814	191320	87	0:30
JFT	13	49	26	GD59	2019	4/21/2019	12:21	544872	185293	97	0:35
JFT	14	50	26	GD63	2019	4/21/2019	14:29	545460	190584	105	0:31
CTD	39	51	26	GD63	2019	4/21/2019	16:49	545401	191235	110	0:07
IKS-80 500	9	51	26	GD63	2019	4/21/2019	17:12	545411	191235	110	0:09
IKS-80 500	10	52	26	GD58	2019	4/21/2019	18:05	545993	190501	103	
CTD	40	52	26	GD58	2019	4/21/2019	19:19	545999	190497	103	
CTD	41	53	26	GD57	2019	4/21/2019	19:39	550992	184896	94	0:06
IKS-80 500	11	53	26	GD57	2019	4/21/2019	19:48	550998	184893	94	0:07
IKS-80 500	12	54	26	GD83	2019	4/21/2019	20:47	551498	183707	77	0:06
CTD	42	54	26	GD83	2019	4/21/2019	20:56	551498	183702	77	0:05
CTD	43	55	26	GD71	2019	4/21/2019	22:19	552336	181908	87	0:07
IKS-80 500	13	55	26	GD71	2019	4/21/2019	22:28	552336	181908	87	0:07
IKS-80 500	14	56	26	GB72	2019	4/21/2019	23:53	553699	181895	95	0:07
CTD	44	56	26	GB72	2019	4/22/2019	0:03	553698	181897	96	0:07
CTD	45	57	26	GB82	2019	4/22/2019	1:40	555297	181196	68	0:04
IKS-80 500	15	57	26	GB82	2019	4/22/2019	1:46	555297	181198	68	0:05
WS-Klein	10	58	26	GB82	2019	4/22/2019	5:58	555095	180676	64	0:02
JFT	15	58	26	GB82	2019	4/22/2019	6:18	555146	180816	63	0:30
IKS-80 500	16	59	26	GB81	2019	4/22/2019	8:46	555497	182894	108	0:06
CTD	46	59	26	GB81	2019	4/22/2019	8:59	555501	182897	108	0:07
JFT	16	60	26	GB81	2019	4/22/2019	9:31	555515	183103	112	0:30
CTD	47	61	26	GB80	2019	4/22/2019	11:00	555698	184285	118	0:09
IKS-80 500	17	61	26	GB80	2019	4/22/2019	11:11	555697	184286	118	0:09
IKS-80 500	18	62	26	GB79	2019	4/22/2019	12:29	555702	190299	117	0:09
CTD	48	62	26	GB79	2019	4/22/2019	12:42	555703	190301	117	0:08
CTD	49	62	26	GB79	2019	4/22/2019	15:45	555702	190286	117	8:15
WS-CTD	6	62	26	GB79	2019	4/22/2019	16:03	555699	190292	117	0:16
WS-CTD	7	62	26	GB79	2019	4/22/2019	16:40	555698	190297	117	0:16
WP2 100	7	62	26	GB79	2019	4/22/2019	17:01	555698	190298	117	0:15
WP2 200	7	62	26	GB79	2019	4/22/2019	17:45	555699	190299	118	0:15
WP2 200	8	62	26	GB79	2019	4/22/2019	18:01	555700	190299	118	0:14
WP2 200	9	62	26	GB79	2019	4/22/2019	18:18	555700	190299	118	0:12
WP3 1000	4	62	26	GB79	2019	4/22/2019	18:34	555701	190299	118	0:13
Bo/BaBo 150, 300, 500	37	62	26	GB79	2019	4/22/2019	18:50	555714	190301	118	0:16
Bo/BaBo 150, 300, 500	38	62	26	GB79	2019	4/22/2019	19:12	555818	190339	116	0:18
IKS-80 500	19	63	26	BG82a	2019	4/22/2019	20:13	560560	190611	125	0:07
CTD	50	63	26	BG82a	2019	4/22/2019	20:26	560559	190690	125	0:08
CTD	51	64	26	GB84	2019	4/22/2019	21:36	561499	185995	122	0:09
IKS-80 500	20	64	26	GB84	2019	4/22/2019	21:48	561501	185999	121	
IKS-80 500	21	65	26	GB90	2019	4/22/2019	23:34	563199	185997	137	0:10
CTD	52	66	26	GB90	2019	4/22/2019	23:50	563200	185998	137	0:08
CTD	53	66	26	GB91	2019	4/23/2019	0:53	564201	190001	142	0:08
IKS-80 500	2	66	26	GB91	2019	4/23/2019	1:09	564206	190006	142	0:02
WP2 100	8	66	26	GB91	2019	4/23/2019	1:12	564209	190010	142	0:13
IKS-80 500	22	67	26	GB90a	2019	4/23/2019	2:37	563205	184595	57	0:04
CTD	54	67	26	GB90a	2019	4/23/2019	2:45	563203	184593	68	0:05
JFT	17	62	26	GB79	2019	4/22/2019	13:07	555761	190177	120	
JFT	18	68	25	BB08	2019	4/25/2019	11:05	554765	160148	62	0:25

JFT	19	69	25	BB07	2019	4/25/2019	13:34	553749	160070	73	0:26
JFT	20	70	25	BB15	2019	4/25/2019	15:12	553377	160375	79	0:29
CTD	55	71	25	BB07	2019	4/25/2019	18:16	553713	160022	75	0:06
WS-CTD	8	71	25	BB07	2019	4/25/2019	18:29	553714	160025	75	
WP2 100	9	71	25	BB07	2019	4/25/2019	18:43	553718	160029	75	0:08
Bo/BaBo 150, 300, 500	39	71	25	BB07	2019	4/25/2019	18:55	553713	160024	74	0:11
Bo/BaBo 150, 300, 500	40	71	25	BB07	2019	4/25/2019	19:13	553723	160175	74	0:10
Bo/BaBo 150, 300, 500	41	72	25	BB10	2019	4/25/2019	20:03	553699	161455	76	0:12
CTD	56	72	25	BB10	2019	4/25/2019	20:18	553751	161490	74	0:05
CTD	57	73	25	BB12	2019	4/25/2019	21:16	553744	163000	63	0:04
Bo/BaBo 150, 300, 500	42	73	25	BB12	2019	4/25/2019	21:23	553750	163025	62	0:10
Bo/BaBo 150, 300, 500	43	74	25	BB11	2019	4/25/2019	22:28	554746	162992	57	0:08
CTD	58	74	25	BB11	2019	4/25/2019	22:40	554754	162994	57	0:09
CTD	59	75	25	BB09	2019	4/25/2019	23:48	554749	161497	60	0:05
Bo/BaBo 150, 300, 500	44	75	25	BB09	2019	4/25/2019	23:55	554754	161500	60	0:07
Bo/BaBo 150, 300, 500	45	76	25	BB08	2019	4/26/2019	0:51	554733	160068	62	0:09
CTD	60	76	25	BB08	2019	4/26/2019	1:04	554749	155997	62	0:04
CTD	61	77	25	BB06	2019	4/26/2019	2:21	553749	154503	70	0:05
Bo/BaBo 150, 300, 500	46	77	25	BB06	2019	4/26/2019	2:28	553750	154505	69	0:10
Bo/BaBo 150, 300, 500	47	78	25	BB05	2019	4/26/2019	3:21	553729	153036	67	0:09
CTD	62	78	25	BB05	2019	4/26/2019	3:33	553746	152996	67	0:05
CTD	63	79	25	BB04	2019	4/26/2019	4:30	553750	151508	75	0:05
Bo/BaBo 150, 300, 500	48	79	25	BB04	2019	4/26/2019	4:39	553745	151499	75	0:11
Bo/BaBo 150, 300, 500	49	80	25	BB03	2019	4/26/2019	5:35	553684	150021	76	0:11
CTD	64	80	25	BB03	2019	4/26/2019	5:50	553741	150001	76	0:06
CTD	65	81	25	BB02	2019	4/26/2019	6:43	553739	144512	69	0:06
Bo/BaBo 150, 300, 500	50	81	25	BB02	2019	4/26/2019	5:51	553741	144517	69	1:10
Bo/BaBo 150, 300, 500	51	82	25	BB01	2019	4/26/2019	7:58	552709	144500	70	0:11
CTD	66	82	25	BB01	2019	4/26/2019	8:12	552762	144495	69	0:05
CTD	67	83	25	BB12	2019	4/26/2019	9:13	552750	145995	78	0:05
Bo/BaBo 150, 300, 500	52	83	25	BB19	2019	4/26/2019	9:21	552760	145975	78	0:12
Bo/BaBo 150, 300, 500	53	84	25	BB18	2019	4/26/2019	10:26	552717	151497	91	0:15
CTD	68	84	25	BB18	2019	4/26/2019	10:44	552781	151502	90	0:07
CTD	69	85	25	BB17	2019	4/26/2019	11:47	552749	153000	85	
WS-Klein	12	85	25	BB17	2019	4/26/2019	11:55	552752	152995	85	0:02
Bo/BaBo 150, 300, 500	54	85	25	BB17	2019	4/26/2019	12:07	552757	152996	85	0:09
Bo/BaBo 150, 300, 500	55	86	25	BB16	2019	4/26/2019	13:03	552696	154433	86	0:10
CTD	70	86	25	BB16	2019	4/26/2019	13:17	552745	154490	85	0:05
CTD	71	87	25	BB15	2019	4/26/2019	14:12	552747	155996	83	0:06
Bo/BaBo 150, 300, 500	56	87	25	BB15	2019	4/26/2019	14:29	552750	155999	83	0:01
CTD	72	87	25	BB15	2019	4/26/2019	14:42	552820	160246	81	0:06
WS-CTD	9	87	25	BB15	2019	4/26/2019	14:55	552823	160248	81	1:11
WS-CTD	10	87	25	BB15	2019	4/26/2019	15:31	552826	160259	81	0:07
WP2 100	10	87	25	BB15	2019	4/26/2019	16:02	552828	160255	81	0:08
WP2 200	10	87	25	BB15	2019	4/26/2019	16:13	552828	060255	81	0:10
WP2 200	11	87	25	BB15	2019	4/26/2019	16:25	552827	160257	81	0:08
WP2 200	12	87	25	BB15	2019	4/26/2019	16:36	552827	160225	81	0:10
WP3 1000	5	87	25	BB15	2019	4/26/2019	16:51	552826	160261	81	0:09
Bo/BaBo 150, 300, 500	57	87	25	BB15	2019	4/26/2019	17:45	552843	160328	81	0:13
Bo/BaBo 150, 300, 500	58	87	25	BB15	2019	4/26/2019	18:01	552868	160447	81	0:13
Bo/BaBo 150, 300, 500	59	88	25	BB14	2019	4/26/2019	18:47	552691	161458	75	0:12
CTD	73	88	25	BB14	2019	4/26/2019	19:02	552747	161497	74	0:05
Bo/BaBo 150, 300, 500	60	89	25	BB13	2019	4/26/2019	19:56	552700	162962	57	0:09
WS-Klein	13	89	25	BB13	2019	4/26/2019	20:08	552746	162999	58	0:01
CTD	74	89	25	BB13	2019	4/26/2019	20:16	552743	163002	58	0:04

CTD	75	90	25	BB26	2019	4/26/2019	21:19	551759	162995	62	0:05
Bo/BaBo 150, 300, 500	61	90	25	BB26	2019	4/26/2019	21:27	551758	163012	62	0:10
Bo/BaBo 150, 300, 500	62	91	25	BB25	2019	4/26/2019	22:32	551743	161481	74	0:12
CTD	76	91	25	BB25	2019	4/26/2019	22:47	551769	161526	74	0:06
CTD	77	92	25	BB24	2019	4/26/2019	23:45	551751	155996	89	0:06
Bo/BaBo 150, 300, 500	63	92	25	BB24	2019	4/26/2019	23:54	551753	160001	89	0:11
Bo/BaBo 150, 300, 500	64	93	25	BB23	2019	4/27/2019	0:54	551726	154582	95	0:11
CTD	78	93	25	BB23	2019	4/27/2019	1:08	551748	154494	95	0:08
CTD	79	94	25	BB22	2019	4/27/2019	2:04	551748	153000	93	0:06
Bo/BaBo 150, 300, 500	65	94	25	BB22	2019	4/27/2019	2:13	551748	152987	93	0:10
Bo/BaBo 150, 300, 500	66	95	25	BB21	2019	4/27/2019	3:01	551704	151766	87	0:10
CTD	80	95	25	BB21	2019	4/27/2019	3:14	551743	151700	88	0:06
CTD	81	96	25	BB20	2019	4/27/2019	4:14	551748	150003	72	0:06
Bo/BaBo 150, 300, 500	67	96	25	BB20	2019	4/27/2019	4:29	551758	150007	72	0:09
WS-Klein	14	96	25	BB20	2019	4/27/2019	4:23	551751	145995	72	0:02
Bo/BaBo 150, 300, 500	68	97	25	BB32	2019	4/27/2019	5:51	550720	151541	61	0:10
CTD	82	97	25	BB32	2019	4/27/2019	6:10	550742	151520	62	0:05
WS-Klein	15	97	25	BB32	2019	4/27/2019	6:02	550772	151519	62	0:03
CTD	83	98	25	BB31	2019	4/27/2019	7:03	550747	152986	67	0:05
Bo/BaBo 150, 300, 500	69	98	25	BB31	2019	4/27/2019	7:10	550750	152980	67	0:10
Bo/BaBo 150, 300, 500	70	99	25	BB30	2019	4/27/2019	8:10	550715	154550	88	0:13
CTD	84	99	25	BB30	2019	4/27/2019	8:26	550758	154459	89	0:06
CTD	85	100	25	BB29	2019	4/27/2019	9:27	550747	155997	87	0:06
WS-Klein	16	100	25	BB29	2019	4/27/2019	9:36	550745	155994	88	0:01
Bo/BaBo 150, 300, 500	71	100	25	BB29	2019	4/27/2019	9:39	550748	155985	87	0:13
Bo/BaBo 150, 300, 500	72	101	25	BB28	2019	4/27/2019	10:47	550797	161422	80	0:14
CTD	86	101	25	BB28	2019	4/27/2019	11:02	550738	161513	79	0:06
CTD	87	102	25	BB27	2019	4/27/2019	11:58	550750	162999	51	0:04
Bo/BaBo 150, 300, 500	73	102	25	BB27	2019	4/27/2019	12:04	550748	162997	51	0:06
Bo/BaBo 150, 300, 500	74	103	25	BB37	2019	4/27/2019	13:21	545774	161549	49	0:07
CTD	88	103	25	BB37	2019	4/27/2019	13:30	545752	161508	49	0:04
CTD	89	104	25	BB36	2019	4/27/2019	14:26	545756	160010	73	0:05
Bo/BaBo 150, 300, 500	75	104	25	BB36	2019	4/27/2019	14:34	545752	155997	73	0:09
Bo/BaBo 150, 300, 500	76	105	25	BB35	2019	4/27/2019	15:30	545780	154587	77	0:09
CTD	90	105	25	BB35	2019	4/27/2019	15:44	545752	154511	80	0:06
WS-CTD	11	105	25	BB35	2019	4/27/2019	16:00	545750	154500	80	0:15
WP2 100	11	105	25	BB35	2019	4/27/2019	16:23	545748	154498	80	0:11
Bo/BaBo 150, 300, 500	77	105	25	BB35	2019	4/27/2019	16:35	545747	154494	80	0:13
Bo/BaBo 150, 300, 500	78	106	25	BB34	2019	4/27/2019	17:33	545787	153097	76	0:10
CTD	91	106	25	BB34	2019	4/27/2019	17:49	545748	153002	76	0:05
CTD	92	107	25	BB33	2019	4/27/2019	18:45	545752	151514	43	0:03
Bo/BaBo 150, 300, 500	79	107	25	BB33	2019	4/27/2019	18:51	545749	151507	43	0:05
Bo/BaBo 150, 300, 500	80	108	25	BB42	2019	4/27/2019	20:05	544799	150066	60	0:09
CTD	93	108	25	BB42	2019	4/27/2019	20:17	544755	150004	60	0:05
CTD	94	109	25	BB41	2019	4/27/2019	21:15	544752	151484	67	0:05
Bo/BaBo 150, 300, 500	81	109	25	BB41	2019	4/27/2019	21:23	544745	151470	67	0:09
Bo/BaBo 150, 300, 500	82	110	25	BB40	2019	4/27/2019	22:26	544792	153013	73	0:11
CTD	95	110	25	BB40	2019	4/27/2019	22:41	544737	152996	73	0:06
CTD	96	111	25	BB39	2019	4/27/2019	23:39	544750	154505	71	0:05
Bo/BaBo 150, 300, 500	83	111	25	BB39	2019	4/27/2019	23:47	544744	154498	71	0:10
Bo/BaBo 150, 300, 500	84	112	25	BB38	2019	4/28/2019	0:46	544790	155967	53	0:08
CTD	97	112	25	BB38	2019	4/28/2019	0:58	454753	160002	52	0:04
CTD	98	113	25	BB45	2019	4/28/2019	2:16	543748	154506	59	0:03
Bo/BaBo 150, 300, 500	85	113	25	BB45	2019	4/28/2019	2:22	543747	154497	59	0:07
Bo/BaBo 150, 300, 500	86	114	25	BB44	2019	4/28/2019	3:16	543771	153063	63	0:06

CTD	99	114	25	BB44	2019	4/28/2019	3:26	543751	153005	61	0:04
CTD	100	115	25	BB43	2019	4/28/2019	4:21	543756	151518	59	0:03
Bo/BaBo 150, 300, 500	87	115	25	BB43	2019	4/28/2019	4:27	543753	151504	58	0:09
JFT	21	116	25	BB43	2019	4/28/2019	6:11	553830	151434	60	0:35
JFT	22	117	25	BB40	2019	4/28/2019	10:06	544791	152976	74	0:22
Bo/BaBo 150, 300, 500	88	118	25	SR55	2019	4/28/2019	17:59	552070	164894	66	0:10
CTD	101	118	25	SR55	2019	4/28/2019	18:14	552098	164800	66	0:05
CTD	102	119	25	SR54	2019	4/28/2019	19:13	552093	170495	67	0:04
Bo/BaBo 150, 300, 500	89	119	25	SR54	2019	4/28/2019	19:27	552127	170459	67	0:09
Bo/BaBo 150, 300, 500	90	120	25	SR53	2019	4/28/2019	20:32	552057	172206	72	0:09
CTD	103	120	25	SR53	2019	4/28/2019	20:45	552105	172171	72	0:06
CTD	104	121	25	SR52	2019	4/28/2019	21:44	552498	173496	66	0:05
IKS-80 500	24	121	25	SR52	2019	4/28/2019	21:51	552498	173499	66	0:06
IKS-80 500	25	122	25	SR49	2019	4/28/2019	22:58	551500	173499	75	0:07
CTD	105	122	25	SR49	2019	4/28/2019	23:09	551498	173507	75	
CTD	106	123	25	SR48	2019	4/29/2019	0:01	551397	172203	89	0:07
Bo/BaBo 150, 300, 500	91	124	25	SR47	2019	4/29/2019	1:15	551449	170548	86	0:11
CTD	107	124	25	SR47	2019	4/29/2019	1:29	551498	170498	83	
CTD	108	125	25	SR46	2019	4/29/2019	2:33	551396	164801	80	0:06
Bo/BaBo 150, 300, 500	93	125	25	SR46	2019	4/29/2019	2:42	551400	164802	79	0:10
JFT	23	125	25	SR46	2019	4/29/2019	6:06	551810	165199	73	0:30
JFT	24	126	25	BB25	2019	4/29/2019	11:58	551814	161595	72	0:30
JFT	25	127	25	BB24	2019	4/29/2019	15:55	551780	160045	88	0:30
CTD	109	128	25	BB23	2019	4/30/2019	0:00	551749	154489	95	0:07
Apstein 50	4	128	25	BB23	2019	4/30/2019	0:11	551749	154488	95	0:18
Apstein 50	5	128	25	BB23	2019	4/30/2019	0:32	551751	154488	95	0:16
Apstein 50	6	128	25	BB23	2019	4/30/2019	0:49	551751	154489	95	0:17
WP2 100	12	128	25	BB23	2019	4/30/2019	1:09	551749	154488	95	0:12
WP2 100	13	128	25	BB23	2019	4/30/2019	1:22	551748	154492	95	0:11
WP2 100	14	128	25	BB23	2019	4/30/2019	1:35	551748	154495	95	0:11
WP2 100	15	128	25	BB23	2019	4/30/2019	1:49	551750	154493	95	0:10
WP2 200	13	128	25	BB23	2019	4/30/2019	2:02	551747	154498	95	0:11
Bo/BaBo 150, 300, 500	94	128	25	BB23	2019	4/30/2019	2:20	551751	154500	95	0:10
WS-CTD	12	128	25	BB23	2019	4/30/2019	6:01	551742	154485	95	0:14
WS-CTD	13	128	25	BB23	2019	4/30/2019	6:37	551751	154485	95	0:14
WS-CTD	14	128	25	BB23	2019	4/30/2019	7:48	551759	154486	95	0:08
WP2 200	14	128	25	BB23	2019	4/30/2019	8:15	551758	154489	95	0:08
MN-midi 50	2	128	23	BB23	2019	4/30/2019	10:00	551751	154498	95	0:09
MN-midi 50	3	128	23	BB23	2019	4/30/2019	10:29	551752	154498	95	0:08
MN-maxi 335	2	128	23	BB23	2019	4/30/2019	12:01	551763	154503	95	0:41
MN-maxi 335	3	128	23	BB23	2019	4/30/2019	13:06	551756	154502	95	0:34
MN-midi 50	4	128	23	BB23	2019	4/30/2019	16:03	551750	154504	95	0:08
MN-midi 50	5	128	23	BB23	2019	4/30/2019	16:23	551750	154504	95	0:06
MN-maxi 335	4	128	23	BB23	2019	4/30/2019	18:35	551789	154408	95	0:39
MN-maxi 335	5	128	23	BB23	2019	4/30/2019	19:23	551818	154337	95	0:35
MN-midi 50	6	128	23	BB23	2019	4/30/2019	21:59	551747	154500	95	0:08
MN-midi 50	7	128	23	BB23	2019	4/30/2019	22:14	551744	154502	95	0:08
MN-maxi 335	6	128	23	BB23	2019	5/1/2019	0:00	551750	154502	95	0:40
MN-maxi 335	7	128	23	BB23	2019	5/1/2019	1:15	551753	154504	95	0:33
MN-midi 50	8	128	23	BB23	2019	5/1/2019	4:00	551751	154500	95	0:08
MN-midi 50	9	128	23	BB23	2019	5/1/2019	4:18	551752	154501	95	0:06
MN-maxi 335	8	128	23	BB23	2019	5/1/2019	5:59	551829	154566	95	0:40
MN-maxi 335	9	128	23	BB23	2019	5/1/2019	6:47	551965	154819	95	0:35

7 Data and Sample Storage and Availability

All data obtained during the cruise have been backed up on a GEOMAR virtual drive that is backed up daily. In addition, data are stored on different hard drives in different locations. Paper protocols filled out during the cruise were entered electronically continuously throughout the cruise, and thus fall under the electronic back-up scheme, but have also been conserved as hard copies to resolve possible data entry errors later on if needed.

All cruise meta-data – including output of the onboard DSHIP-System - have been entered in the GEOMAR Ocean Science Information System (OSIS), managed by the Kiel Data Management Team (KDMT), and intended for permanent archiving of such data. The data are freely available via the link <https://portal.geomar.de/metadata/leg/show/34864> (keyword “AL521”).

We aim to ultimately make all data accumulated during the cruise publicly available. All hydrographic (CTD) data will be submitted to the ICES database within one year from the cruise. Moreover, the KDMT team will assist with the publication of data in the public data repository PANGAEA to provide long-term archivation and access to the data. Depending on the data set, some of the data are intended for specific publications, and will be published openly with the appearance of the underlying peer-review article. In these cases, please contact the person responsible for the data in case earlier access to the data is desired (Table 7.1).

All samples obtained during the cruise were labelled on board with a barcoding scheme, and all samples intended for longer-term storage were professionally archived immediately after the cruise. This includes formalin conserved samples for long-term storage, and frozen samples (-20°C and -80°C) currently conserved in freezer rooms at GEOMAR.

Table 7.1 Overview of data availability and persons responsible for specific data sets.

Type	Database	Available	Free Access	Contact
Hydrography (CTD data)	ICES database	Publicly by April 2020, earlier on request (see contact e-mail).	By April 2020	jdierking@geomar.de
Fishery data and food web sampling data	PANGAEA	Publicly at time of acceptance of the underlying peer-reviewed publication; alternatively via request (see contact e-mail).		jdierking@geomar.de
Ichthyoplankton data	PANGAEA	See above.		clemmesen@geomar.de
Hydroacoustic data	PANGAEA	See above.		matthias.schaber@thuenen.de
Phytoplankton community sampling		Inquire with collaboration partner (see contact e-mail).		luisa.listmann@uni-hamburg.de
eDNA sampling		Inquire with collaboration partner (see contact e-mail).		monika.winder@su.se

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9 Appendices

Appendix 9.1 Selected Pictures of Shipboard Operations

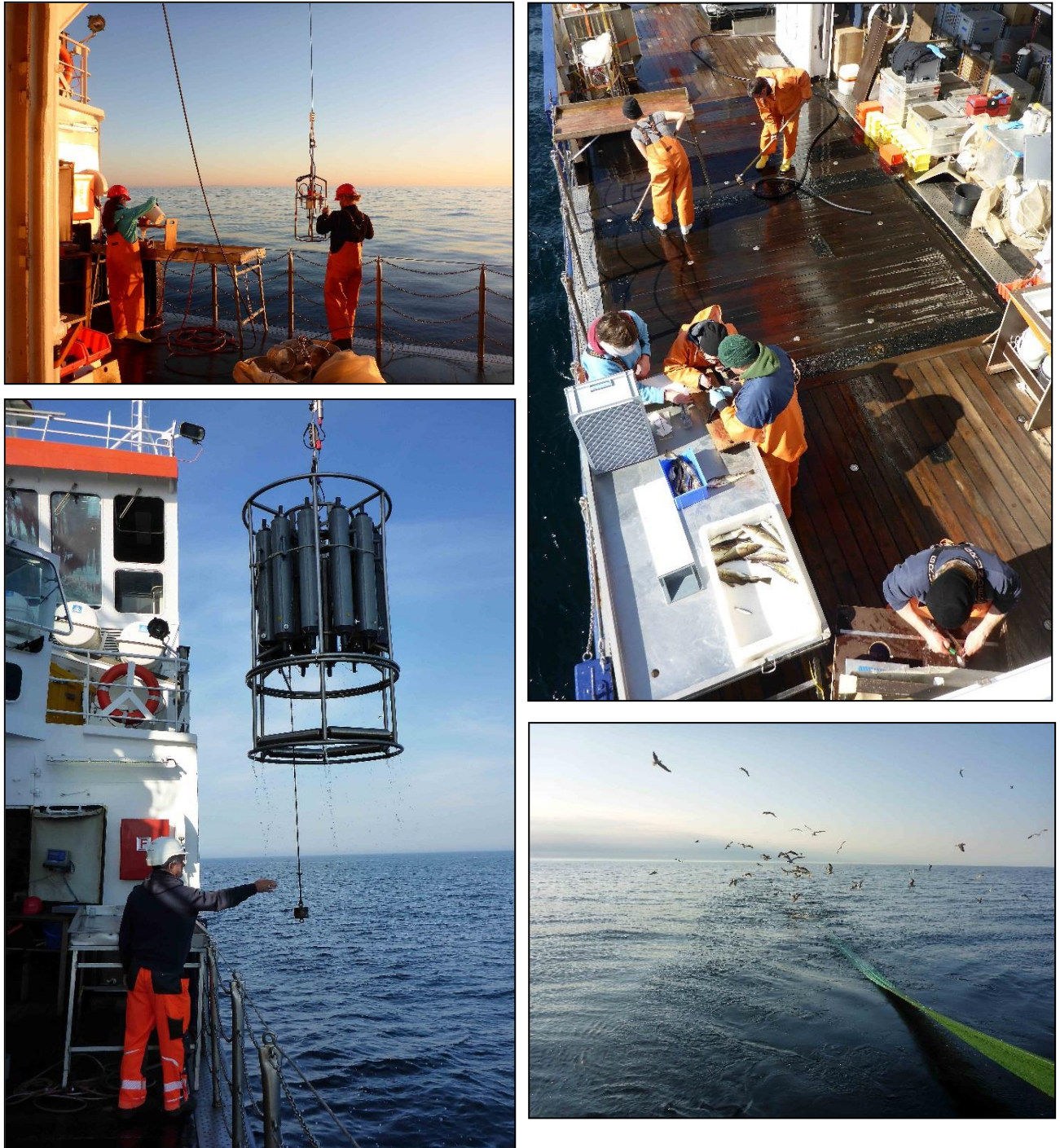


Figure 9.1.1 Impressions of cruise AL521. Clockwise from top left: CTD deployment and plankton filtering; fish sampling on board; trawl net coming in; water sampler coming back on board. Photos: J. Dierking